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(54) ENERGY-STORING PROSTHETIC LEG PYLON

ENERGIESPEICHERNDE PYLONE EINER FUSSPROTHESE

PYLONE DE PROTHESE DE JAMBE STOCKANT L'ENERGIE

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Description

This invention relates to leg prostheses in general, and specifically to a prosthetic device and a pylon which is capable of storing and subsequently releasing energy during use. The pylon may be of a lightweight construction, and preferably may be modified and adjusted to accommodate an individual wearer's needs and particular uses.

Moreover, the pylon of the invention may be utilized in connection with any of a broad selection of prosthetic sockets for attachment to the wearer, as well as in connection with any of a broad selection of prosthetic feet attached to, or integrally formed with, the lower end of the pylon.

Various types of foot and leg prosthetic devices are known in the prior art. Such devices generally include some form of attachment for coupling the device to the dorsal end of the limb and for extending to the ground to provide body support. Moreover, these devices generally constitute attempts to simulate the structure and/or the performance of the human leg and foot.

Among the features desirable in leg and foot prostheses is the incorporation of some means for storing and releasing energy during use of the prosthesis; for example, during ambulation. Such energy performance permits the wearer to expend less energy and to participate in activities not otherwise feasible to the wearer. Consequently, the wearer becomes less tired, is able to perform for longer periods of time. In many ways, energy-storing and releasing prostheses remove barriers and limitations which might otherwise restrict the wearer's activities. Examples of prostheses which provide energy storage and release are set forth in United States Patent US-A-4,547,913 for my invention relating to a "Composite Prosthetic Foot and Leg", United States Patent US-A-4,822,363 for my invention relating to a "Modular Composite Prosthetic Foot and Leg", and United States Letters Patent US-A-5,037,444 for my invention relating to a "Prosthetic Foot".

Although the benefits and desirability of energy storage and release in prosthetic devices is known, no prior art prosthetic devices provide those benefits in the relatively simple construction, which is adaptable to wide variety of applications, is readily manufacturable and adjustable, and permits an extremely sensitive energy performance.

The United States Patent US-A-2,699,554 discloses an artificial limb comprising an upper leg member and a lower leg member, with a spring operably engaging the first and second leg members. The artificial limb also comprises a foot member resiliently connected to the lower side of the lower leg member. The upper and lower members are adapted to slide relative to one another in response to the imposition of a load on the artificial limb. This US document has been used in forming the preamble of the attached Claims 1 and 25.

Other examples of such prosthetic foot devices include US-A-2,075,583 to Lange, which incorporates a rubber form mounted in operative relationship with a rigid metallic core, and US-A-4,645,509 to Poggi, which teaches a prosthetic foot incorporating a monolithic keel or beam of relatively massive proportions intended to react to the load of an amputee's body during walking, running, jumping, and the like and to release the resultant stored energy to create foot lift and thrust complementing the amputee's natural stride.

Some of the benefits of my previous inventions disclosed in my aforementioned patents reside in the interchangeable, lightweight construction which provides selectable degrees of strength and flexibility in a given structure. The present invention should permit similar interchangeability, providing additional or alternative control and adjustability of the performance of the prosthesis. Moreover, my present invention should provide some degree of those adjustability and performance benefits to wearers of otherwise conventional or non-energy-storing prosthetic devices.

It is, therefore, an object of my invention to provide an energy-storing prosthetic pylon which may be incorporated in a prosthetic leg device. According to the present invention, a pylon is provided as defined in claim 25. Upper and lower pylon members are preferably overlappingly interengaged and reciprocable one on the other. This interengagement of the upper and lower pylon members may be accomplished, for example, through the provision of an interfitting, slidably disposed sleeve and arm configuration for the pylon members. Forces imposed on the pylon cause the aforesaid reciprocation of the pylon members and the corresponding storage of energy in the spring element or elements.

Among other things, the interengagement of the upper and lower pylon members assists in maintaining appropriate alignment of the pylon during use. Notably, such alignment may include one or more dynamic components; for example, in addition to the energy-storing compression which is one of the primary functions of the pylon, the alignment of the pylon members may permit rotation of "toe-in" and/or "toe-out" during use, such as is accomplished by known prosthetic "rotators". In other words, during use by the wearer, the preferred embodiment of the invention permits a desired and determinable amount of rotation of the lower end of the pylon with respect to the wearer's socket. Such rotation is beneficial, and simulates the action of a natural human knee/ankle, in a number of activities that involve the twisting of a person's body with respect to their planted foot, such as golf, tennis, and the like.

According to the present invention, a prosthetic device is also provided as defined in claim 1. The device preferably includes an upper extremity adaptable for securement to the wearer's limb and a lower extremity adaptable for securement to a prosthetic foot, with the aforesaid energy-storing means as one or more elongated spring elements interconnecting or acting between the two extremities. In the preferred embodiment, the specific interconnection of the spring elements to the pylon extremities is preferably of a pivoting

nature. Such a pivoting structure eliminates or greatly reduces the stress concentrations that would otherwise be present during compression of the pylon and spring elements. Non-pivoting interconnection of the spring to the pylon members could, of course, be utilized without departing from the teachings of the invention. When such pivoting structures are utilized, however, it is preferable to minimize the friction inherent in such a pivot. Any friction which occurs in the pivoting action results in a loss energy which could otherwise be stored in the energy storage means and subsequently released beneficially to the amputee. A preferred measure for minimizing this friction loss is to coat contacting surfaces with teflon or similar material, as discussed herein.

The particular selections of a device for attachment to the wearer and of a prosthetic foot may be permanently or demountably associated with the pylon. Demountable association permits one or more of the socket, the pylon, and/or the leg and foot prostheses components to be readily exchanged with correspondingly constructed elements to provide size adjustment and/or different energy-performance characteristics to suit the size of leg and foot of the amputee or the stride, height, weight, and activity level of the amputee. Therefore, a range of combinations of spring rate and size can be provided to the amputee. Moreover, manufacture and inventory costs are reduced because prostheses appropriate for amputees of greatly differing heights and weights can be assembled from a relatively small inventory of "standard" sized components.

In another preferred embodiment, the spring elements are fabricated from laminates, chopped fiber and/or other material maintained in operative relationship by an encapsulating polymer such as a thermosetting or thermoplastic resin.

In operation of the present invention, when a contact-generated compressive force is impressed upon the lower member, it will be reciprocated relatively to said upper member to compress the energy storage means into an energy storage mode, and when said force is released the storage means will urge the lower member to its extended position.

Another embodiment of the invention, provides a multiplicity of said spring elements utilized in combination with each other to vary the resistance of the prosthesis to loads imposed thereupon. The concept of the multiplicity of spring elements includes the provision of spring elements characterized by different spring rates, which permits the resistance of the total combination to deflection to be precisely adjusted to the weight, activity level and other characteristics of the individual for whom said pylon is being adjusted.

Yet another embodiment of the invention is the provision of a prosthesis of the afor-menti-ned character having elongated spring elements and further including constraining means such as, for example, an elastic cord for constraining the amount of deflection of the one or more elongated spring elements. Such constraining means provide an additional means to "fine-tune" the energy performance of the prosthesis.

In order to impart a cosmetic aspect to the prosthetic leg device, after proper fitting of the leg to insure that it is properly balanced and of appropriate size, the prosthesis may be encapsulated in a suitably shaped cosmetic shroud. The shroud must be sufficiently flexible so as not to inhibit the free movement and flexure of the leg, but, because of the inherently resilient and stress-absorbing characteristics of said leg, little or no dependence is needed upon the ancillary cushioning action of the shroud. Moreover, the shroud should accommodate any desired flexure of the energy-storage means without incurring damage or undesirably restricting such flexure.

Consequently, prosthetists and wearers will be able to adjust the flexibility of the pylon at their discretion. Through the provision of preferably demountable, adjustable attachment means such as gripping clamps for attaching the prosthetic foot to the pylon, the pylon may be provided in standard lengths but still be readily "custom-fitted" to a wide range of effective lengths.

Other objects and advantages of the invention will be apparent from the following specification and the accompanying drawings, which are for the purpose of illustration only.

FIG. 1 is a side elevation view of a preferred embodiment of a prosthesis;

FIG. 2 is a sectional view, taken along line 2-2 of FIG. 1;

FIG. 3 is a partial rear elevation view, taken along line 3-3 of FIG. 1;

FIG. 4 is a partially sectional rear view, taken along line 4-4 of FIG. 1;

FIG. 5 is an exploded view of a preferred embodiment of spring elements;

FIG. 6 is a side elevation view of an alternative embodiment of the invention, illustrating the disposition of the lower pylon member internally of the upper pylon member, and further illustrating the use of constraining means in connection with the elongated spring element;

FIG. 7 is a side elevation view illustrating one alternative form of the elongated spring element;

FIG. 8 is a side elevation view of another alternative embodiment of the invention, in which the upper and lower pylon members have a non-circular cross-section;

FIG. 9 is a sectional view, taken along line 9-9 of FIG. 8;

FIG. 10 is a side elevation view of another alternative embodiment of the invention, illustrating an alternative means for attaching the lower prosthetic foot to the energy-storing pylon;

FIG. 11 is a sectional view, taken along line 11-11 of FIG. 10;

FIG. 12 is a side elevation view of another alternative embodiment of the invention;

FIG. 13 is a sectional view, taken along line 13-13

of FIG. 12;

FIG. 14 is a partially sectional, side elevation view of another alternative embodiment of the invention;

FIG. 15 is a partial front elevation view, taken along line 15-15 of FIG. 14; and

FIG. 16 is a partially sectional, front elevation view, taken along line 16-16 of FIG. 14.

Description of Preferred Embodiments

FIG. 1 shows a lower leg prosthesis 10 constructed and assembled in accordance with one embodiment of the invention and including a prosthetic pylon 12. For purposes of illustration, the prosthesis 10 is shown as including a prosthetic foot 14 and as having an attachment means 16 at an upper end thereof for operatively attaching the prosthesis 10 to a wearer, through the use of a socket may be expedient (illustrated, by way of example, as the socket 90, FIGS. 17 and 19).

In the preferred embodiment, and as best shown in FIGS. 3 and 4, the pylon 12 includes pylon means having a first portion constituting an upper member 18 and a second portion constituting a lower member 20. As shown in the drawings, these first and second portions are preferably slidingly and reciprocably interengaged with each other in the manner of a sleeve member and an arm member, while retaining their operative horizontal alignment with each other through a relatively close fit between the outside dimensions of the member 18 and the inside dimensions of the lower member 20.

Although the upper and lower members 18 and 20 are illustrated and described as being circular and tubular and coaxially aligned with each other, those skilled in the art will understand that a wide variety of shapes, sizes and alignment patterns may be utilized with efficacy. By way of example, but not by way of limitation, the upper and lower members 18 and 20 may have cross-sections which are square (see FIGS. 11 and 12), rectangular, or D-shaped, or may be solid instead of hollow (see, for example, member 76 of FIG. 15).

Additionally exemplary of the variety of configurations of the pylon members is FIG. 6, discussed below, in which the lower portion 20 may be disposed on the interior of the upper portion 18. In such an embodiment, the respective upper and lower portions must be of sufficient length to otherwise permit the desired unimpeded reciprocation of the prosthesis, as described below.

Moreover, the cylinders 18 and 20 are preferably fabricated from composites of fiber and resin, similar to the prostheses described in my above-listed patents. Such fibers may include, for example, carbon graphite, fiber-glass, Kevlar or a similarly strong, light-weight material. The fiber may be in laminated or chopped form. These fibers are preferably retained in th desired operative configuration by polymer impregnation of a thermoplastic or thermosetting resin, such as epoxy, polyester, vinylester, polyethylene or polypropylene. Less expensive materials may be utilized for the pylon members, such as aluminum or extruded nylon, although such materials are heavier.

To enhance the energy storage and release performance of the pylon assembly 12, as more thoroughly described herein, the contiguous surfaces of the cylinders are preferably coated with teflon, silverstone, a teflon-like fabric, or some similar material to minimize any frictional resistance therebetween.

In the preferred embodiment, the energy storage means 22 includes elongated spring elements such as elements 24 and 26, fabricated from the above-described composite materials to provide the necessary energy storage and release. The device has one element 24 or 26, or may have additional such elements. When a plurality of such elements is utilized, as illustrated in the drawings, they may be assembled in operative relationship with each other through the use of, for example, a nut and bolt combination 28. A protective cap 29 may be provided on the end of the bolt 28.

An alternative embodiment of the elongated spring elements 24 and 26 is shown in FIG. 7 with the multi-curvilinear spring 60.

At least one of the preferred spring elements 24 or 26 is operatively connected to the upper and lower pylon portions 18 and 20, such as through the provision of pivotal attachment means 30 and 32. As best shown in FIG. 5, the attachment means 30 and 32 preferably includes tubular cap members 34 and 36 at the respective upper and lower extremities of the spring element 24. The caps 34 and 36 are slidably received in corresponding respective channels 38 and 40, FIG. 4, and retained there by set screws 42, locking nuts 44 or the like.

The caps 34 and 36, as well as the channels 38 and 40, are preferably coated with teflon, silverstone, or similar material to minimize friction therebetween. Among other things, minimizing the friction between these interfaces and between the contacting surfaces of the upper and lower pylon members 18 and 20 (as described above) reduces the loss of energy due to friction during reciprocation of the pylon. Because of the low amount of friction which must be overcome, the prosthesis 10 can provide cushioning and energy-storage, as more fully described below, for even relatively small compressive loads, with relatively low losses of energy due to friction.

Alternative means for attaching the spring elements 24 and/or 26 to the pylon members 18 and 20 would include, for example, standard hinges (not shown). An example of one of the other many further alternatives for attachment is illustrated in FIGS. 14-16, discussed herein.

Other purposes of the preferred attachment means 30 and 32, in combination with the spring element 24, include the prevention and/or limitation of rotational movement between the respective cylinders 18 and 20. With proper selection of materials and configurations of the cap members 34 and 36 and the spring element 24 (such as size, width, thickness, stiffness and strength of materials), all rotation can be prevented, or some

desired and determinable amount of rotation of the lower end of the pylon with respect to the wearer's socket may be permitted. As indicated above, this rotation is similar to that achieved by known prosthetic "rotators". Such rotation is beneficial, and simulates the action of a natural human knee/ankle, in a number of activities that involve the twisting of a person's body with respect to their planted foot, such as golf, tennis, and the like.

By way of example, but not by way of limitation, a wider or stiffer spring element 24 would permit less rotation than a relatively narrower and/or "softer" spring element. Such stiffness of the spring element may be determined, for example, by the number of fiber laminates utilized in the fabrication thereof, if the spring element is fabricated of laminates. If the spring is fabricated from other materials, the particular selection and/or treatment process may be utilized to affect the twisting performance, or the upper and lower pylon members 18 and 20 may be "keyed" to each other to prevent or limit twisting.

In the absence of some control or limitation on such twisting of the cylinders 18 and 20 with respect to each other, such twisting could, for example, cause the lower portion of the prosthesis (in the drawings, the prosthetic foot 14) to become misaligned with respect to the wearer's socket.

As indicated above, the spring elements 24 and 26, as well as other components of the present invention, are preferably formed by the incorporation of a plurality of laminae such as the laminae 58, FIG. 2, embedded in a hardened, flexible polymer, similar to the fabrication methods taught in my above-noted prior art patents. Alternative materials include chopped fiber and thermosetting and/or thermoplastic resins. Such fabrication of the spring elements permits the desired energy storage and release characteristics of the spring, achieving a desired balance between sufficient durability to withstand cyclic loading which may be imposed on the spring and flexibility to cushion impacts of the prosthesis on the ground or other surface and store and release the consequent energy.

The preferred method of manufacturing the spring elements 24 and 26 of the prosthesis 10 is by a thermosetting molding process including the utilization of molds having properly shaped and sized cavities. The cavities are designed to receive the requisite number of laminates and the proper volume of polymer, such that the leg elements 24 and 26 are respectively unitary structures.

As alluded to above, in the preferred embodiment, the lower portion 20 is preferably demountably and adjustably attached to a prosthetic foot 14, although those skilled in the art will understand that the pylon may be utilized in a variety of other manners, such as with a permanently attached or simultaneously- and integrally-formed prosthetic foot member 14 (see, for example, FIGS. 12 and 13 and discussion of same herein). The preferable means for attachment 46 includes a clamp member 48 affixed to the lower pylon through the provision of threaded nut and bolt combinations 50, FIGS. 1 and 2, or similar expedient (such as simultaneous formation therewith). In the preferred embodiment, the clamp member 48 may be operably attached at any of a variety of locations along the length of the lower pylon portion 20 by simply positioning the clamp and tightening the nut and bolt combinations 52. This also permits the adjustment of the "toe-in", "toe-out", fore-and-aft alignment of the foot 14 with respect to the socket (see, by way of example, socket 90, FIGS. 14 and 16.

One of the many alternative means for adjusting and attaching the lower leg prosthesis to the lower pylon is illustrated in FIGS. 10 and 11. The foot prosthesis 14 may be operably retained at a selected position along the length of the lower pylon by one or more hose clamps 66. Presently, it appears that high-strength, heavy duty, wide stainless steel clamps should be utilized. The clamps are adjustable by screws assemblies 68 or similar expedient.

The strength and consequent performance of the attachment of the foot prosthesis 14 may be improved by the provision of a resin or composite wedge 64, FIGS. 10 and 11, formed on the rearward surface of the foot prosthesis 14. The wedge is shaped to conform to the confronting surface of the pylon, and increases the contact area between the foot 14 and the pylon, adding stability to the attachment.

After an amputee has worn the device as illustrated in FIGS. 10 and 11 for some suitable period in order to test the length adjustment and energy performance thereof, the foot 14 may be permanently or semi-permanently bonded in place through the use of known gluing and/or lamination techniques.

Although cap member 29, FIGS. 3 and 4, is shown as contacting the clamp member 48, those skilled in the art will understand that such contact is not required for the practice of the invention. Indeed, and as set forth below, the imposition of force on the pylon 12 will cause the spring element 24 to flex outwardly, away from the pylon portions 18 and 20, correspondingly moving the cap member 29 away from the portions 18 and 20.

A shroud 54 (shown in phantom in FIG. 1) may be provided for a cosmetic finish. Such a shroud may be installed after the judicious adjustment of the prosthesis by the proper combination of elements 18, 20, 24 and/or 26, as well as foot means 14. The shroud should be designed to accommodate and permit the desired flexure and functioning of the prosthesis, without interfering therewith. A shoe 56 or other appropriate covering may also be worn in connection with the assembled prosthesis.

When external forces are applied to the prosthesis 10, such as during walking, running, etc., the forces cause a relative compression of the length of the pylon means 12. As best shown in FIGS. 3 and 4, the first pylon portion 18 will slide downwardly within the second portion 20. Contemporaneously, and as indicated

above, the energy storage and release spring elements 24 and 26 will bow outwardly and away from the pylon members 18 and 20.

The amount of compression, and indeed the energy-storage and release characteristics of the prosthetic pylon, will be determined in large part by the construction and materials of the element or elements 24 and 26. Prior to the imposition of such force, the spring elements maintain the lower member 20 in an extended position relative to the upper member 18. When, for example, a contact-generated compressive force is impressed upon the lower member, the lower member 20 will be reciprocated relative to said upper member 18, to compress said storage means into an energy storage mode. When the force is released, the energy storage means will urge the lower member 20 to its extended position.

As illustrated in the drawings, the secondary spring element 26 will not affect the performance of the prosthesis unless and until a sufficiently large compressive force is imposed on the pylon. In such case, the primary spring element 24 will flex to a sufficient degree to permit the secondary element 26 to engage the primary element 24, resulting in a combined resistance to further deflection.

The energy performance of the pylon 12 may be further controlled and/or fine-tuned through the provision of constraining means 70 such as one or more rubber or urethane bands or rings 72, FIG. 6. This band or these bands are preferably dimensioned so that they may be retained about the prosthesis in a position above or below (not shown) the spring element when the prosthesis is in normal use. In this normal position, the band would not affect the energy performance of the prosthesis. In anticipation of heavy impact loading of the prosthesis, however, such as might occur during running or other strenuous exercise, the band 72 may be positioned as illustrated in FIG. 6, so that its elastic resistance to stretching adds to the overall resistance to compression, or "stiffness", of the prosthesis.

FIG. 6 further illustrates an alternative embodiment of the pylon in which an upper pylon member 74 is disposed externally of a lower pylon member 76. In such a configuration, although the foot prosthesis 14 may be selectively positioned along the length of the lower member 76, it must be sufficiently spaced from the upper member 74 to ensure that the desired reciprocation of the pylon members 74 and 76 can occur.

As indicated above, FIG. 7 illustrates one other form of spring element, indicated as element 60. This element may be utilized in combination to the other spring elements as defined in the attached claims (such as, for example, constraining means 70 of FIG. 6).

FIGS. 8 and 9 illustrate one of the many alternative cross-sections for the upper and lower pylon members. In this embodiment, both the lower member 86 and the upper member 88 incorporate rectangular cross-sections, FIG. 9, which are dimensioned to provide the desired sliding interfitment discussed above.

FIGS. 12 and 13 illustrate an alternative embodiment, in which a prosthetic foot 14 is integrally formed with the lower pylon member 76. Such an embodiment may incorporate, for example, a slightly modified version of the prosthetic leg and foot sold under the trademark FLEX-FOOT®. Appropriate modifications to that leg and foot would include coating the portion 76 (disposed internally of the sleeve member 74) of the leg with teflon, silverstone, or similar low-friction material, and bonding or otherwise attaching the energy-storage means 24 to the foot 14, such as indicated at 75.

FIGS. 14-16 illustrate yet another embodiment, in which the elongated spring member 92 is operatively connected to the upper pylon member 94 and the lower pylon member 96 in a manner different from those described above.

With respect to the connection between the upper pylon member 94 and the spring 92, a channel 98 is provided in the top portion of the upper pylon member 94. The channel 98 is slightly wider than the spring 92 and the base of the channel is preferably configured so that the upper end of spring member 92 is adjacent thereto when the spring is in a non-compressed state (such as illustrated in FIGS. 14-16) A threaded bolt 100 is operatively mounted (by bonding or similar expedient) in the base of the channel 98 and projects therefrom through a hole 102 in the upper end of spring member 92 and through a hole 104 in the socket member 90. The bolt 100 is preferably threaded only near the outer end of the bolt, in order to engage a nut 106; the remainder of the shaft of the bolt 100 is smooth and may be coated with teflon or similar material in order to minimize friction during compression of the spring.

The connection between the lower pylon member 96 and the spring 92 may preferably be assembled in the following manner. A cap member 108 is threadedly engaged on the lower end of the lower pylon member 96. The cap includes an opening 110 in one side, which is sized to permit the spring member 92 to flex during compression of the pylon without contacting the sides of the opening 110. Similarly to the base of the channel 98 described above, the end of the lower pylon member 96 is shaped to conform to the non-compressed spring 92 adjacent thereto. In addition, the end of the lower pylon member 96 includes a threaded hole 112.

To assemble the embodiment of FIGS. 14-16, the lower end of the spring 92 is inserted into the opening 110 and a hole 114 in the spring 92 is positioned between the threaded hole 112 in the bottom of the pylon member 96 and a hole (not shown) in the cap member 108. In order to permit the spring 92 to be fully inserted, the end 118 of the spring 92 is preferably shaped to conform to the confronting annular wall of the cap member 108. A threaded bolt 116 is then inserted through the hole (not shown) in the cap member 108, through the hole 114 in the lower end of the spring element 92, and then threadedly engaged with the hole 112 in the bottom of the pylon member 96. As with the upper bolt 100, the bolt 116 is preferably threaded only

on the portion of the bolt that engages the threaded hole 112. The remainder of the bolt 116 is preferably smooth and may be coated with teflon or similar material in order to minimize friction during compression of the spring.

The attachment configuration of FIGS. 14-16 provides numerous advantages. For example, the spring element 92 can be configured with a longer and smoother curvature than that permitted in, for example, the embodiment of FIG. 1. In addition, as the pylon and the spring element 92 are compressed during use, the ends of the spring element 92 will correspondingly move away, respectively, from the curved base of the channel 98 and the curved bottom of the lower pylon member 96, and will move into contact with, respectively, the bottom 120 of the socket 90 and the interior surface 122 of the cap member 108. The area of this contact increases as the compression of the spring 92 increases, and causes an effective shortening of the lever arm by which force is transmitted to the spring. In effect, the spring 92 becomes "stiffer" (exerts a greater resistance to flexure) in proportion to the amount of force exerted thereon. This permits an extremely desirable energy performance, in that the initial loading of the pylon is readily stored by the spring 92, but extreme loading will meet with more "stiffness".

The holes 102 and 114 are preferably sufficiently sized and configured (and may be teflon-coated as well) so that, during the compression of the pylon and consequent flexure of the pylon spring element 92, any contact between the holes and their respective bolts 100 and 116 results in minimal frictional energy loss.

In the prosthetic device of my invention, a leg prosthesis pylon is provided which can be carefully matched to the weight, stride and physical characteristics of the wearer. This is accomplished by carefully selecting and balancing the respective physical characteristics of the energy storage means 22 and the other portions of the pylon.

Moreover, the various components and portions of the elements may be provided in a variety of sizes, thicknesses, and materials which may be interchangeable with correspondingly-shaped components to permit fine-tuning of the prosthesis to the needs of the wearer thereof. The pylon may also be used in combination with numerous prior art prosthetic devices to improve the performance of such prior art devices.

Claims

1. A prosthetic device comprising:

   a first pylon member (18) and a second pylon member (20) associated with said first pylon member;

   at least one spring (24) operably engaging said first and second pylon members (18, 20), said spring (24) being capable of storing and releasing energy in response to the imposition of loads on said prosthetic device; and

   a prosthetic foot member (14) secured to said second pylon member;

   characterized in that
   said at least one spring comprises a leaf spring (24) arranged to flexibly control the relative axial and rotational movement of said first and second pylon members (18, 20).

2. The prosthetic device of Claim 1, wherein said foot member (14) is adjustably secured to said second pylon member (20), such that said foot member (14) can be axially and rotationally adjusted relative to said second pylon member.

3. The prosthetic device of Claim 1 or 2, wherein said foot member (14) has a clamp (48) which can be used to secure said foot member to said second pylon member (20).

4. The prosthetic device of Claim 3, wherein said clamp (48) can be tightened and secured about said second pylon member (20) with at least one nut and bolt member (52).

5. The prosthetic device of any one of the Claims 1 to 4, wherein said foot member (14) is rotatably secured to said second pylon member (20) to permit said foot member to be positioned having the toe in or toe out.

6. The prosthetic device of any one of the Claims 1 to 5, wherein said leaf spring (24) extends along the side of said first and second pylon members (18, 20), wherein upon placing a load on said prosthetic foot member (14), said first and second pylon members slide relative to one another, thereby compressing said leaf spring (24) and causing said leaf spring to deflect outward.

7. The prosthetic device of any one of the Claims 1 to 6, wherein said leaf spring (24) is pivotably secured to said first and second pylon members (18, 20).

8. The prosthetic device of any one of the Claims 1 to 6, wherein said leaf spring (24) is detachably secured to said first and second pylon members (18, 20).

9. The prosthetic device of any one of the Claims 1 to 8, wherein a retainer (70) is provided to confine and resist the excessive bending of said leaf spring (24).

10. The prosthetic device of any one of the Claims 1 to 9, wherein a secondary spring member (26) is

secured to said leaf spring (24), said secondary spring member (26) having flexible ends which are engaged as said leaf spring (24) deflects to resist the excessive bending of said leaf spring.

11. The prosthetic device of any one of the Claims 1 to 10, wherein said first and second pylon members (18, 20) are coaxially aligned with respect to one another.

12. The prosthetic device of any one of the Claims 1 to 11, wherein said first and second pylon members (18, 20) are concentrically aligned with respect to one another.

13. The prosthetic device of any one of the Claims 1 to 12, wherein at least a portion of the surface between said first and second pylon members (18, 20) is coated with Teflon.

14. The prosthetic device of any one of the Claims 1 to 12, wherein at least a portion of the surface between said first and second pylon members (18, 20) is coated with Silverstone.

15. The prosthetic device of any one of the Claims 1 to 12, wherein at least a portion of the surface between said first and second pylon members (18, 20) is coated with a low friction material.

16. The prosthetic device of any one of the Claims 1 to 15, wherein said leaf spring (24) is fabricated from superimposed laminates.

17. The prosthetic device of any one of the Claims 1 to 16, wherein said first and second pylon members (18, 20) are tubular in configuration.

18. The prosthetic device of any one of the Claims 1 to 16, wherein said first and second pylon members (18, 20) have a square cross-sectional configuration.

19. The prosthetic device of any one of the Claims 1 to 16, wherein said first and second pylon members (18, 20) have a rectangular cross-sectional configuration.

20. The prosthetic device of any one of the Claims 1 to 16, wherein said first and second pylon members (18, 20) have a D-shaped cross-sectional configuration.

21. The prosthetic device of any one of the Claims 1 to 20, wherein said leaf spring (24) is partially or completely fabricated from a thermosetting resin.

22. The prosthetic device of any one of the Claims 1 to 20, wherein said leaf spring (24) is partially or completely fabricated from a thermoplastic resin.

23. The prosthetic device of any one of the Claims 1 to 20, wherein said leaf spring (24) is partially or completely fabricated from chopped fiber.

24. The prosthetic device of any one of the Claims 1 to 19, wherein said leaf spring (24) is partially or completely fabricated from superimposed laminates.

25. A pylon for use with a prosthetic foot for supporting an amputee relative to the ground, comprising:

an upper pylon member (18) and a lower pylon member (20) coaxially aligned with said upper member, said lower member (20) and said upper member (18) being adapted slide relative to one another in response to the imposition of loads on the pylon, and

a flexible spring member (22) connected to said upper and lower members (18, 20), said spring member being adapted to store and release energy,

characterized in that
said flexible spring member includes a leaf spring (24) and is arranged to control the relative axial and rotational movement of said upper and lower members (18, 20), said spring member (24) deflecting non-coaxially relative to the common axis of said upper and lower pylon members (18, 20).

26. The pylon of Claim 25, wherein said spring member (22) deflects outward as said upper and lower pylon members (18, 20) slidably move closer together.

27. The pylon of Claim 25 or 26, wherein said leaf spring (24) is adapted to flexibly resist the rotational movement of said upper member relative to said lower member.

28. The pylon of Claim 25, 26 or 27, wherein an auxiliary spring member (26) is provided to limit the excessive deflection of said spring member (24).

Patentansprüche

1. Prothesenvorrichtung, mit:

einem ersten Stützelement (18) und einem dem ersten Stützelement zugeordneten zweiten Stützelement (20);

mindestens einer Feder (24) die in Betriebseingriff mit dem ersten und zweiten Stützelement (18, 20) steht, wobei die Feder (24) in der Lage ist, Energie als Reaktion auf die Aufgabe von Belastungen auf die Prothesenvorrichtung zu

speichern und abzugeben; und

einem Fußprothesenelement (14), das an dem zweiten Stützelement befestigt ist;

dadurch gekennzeichnet, daß
die mindestens eine Feder eine Blattfeder (24) aufweist, die für eine flexible Steuerung der relativen Axial- und Rotationsbewegung des ersten und zweiten Stützelementes (18, 20) angeordnet ist.

2. Prothesenvorrichtung nach Anspruch 1, wobei das Fußelement (14) einstellbar in der Weise an dem zweiten Stützelement befestigt ist, daß das Fußelement (14) axial und drehbar in Bezug auf das zweite Stützelement eingestellt werden kann.

3. Prothesenvorrichtung nach Anspruch 1 oder 2, wobei das Fußelement (14) eine Klammer (48) aufweist, welche dazu verwendet werden kann, das Fußelement an dem zweiten Stützelement (20) zu befestigen.

4. Prothesenvorrichtung nach Anspruch 3, wobei die Klammer (48) um das zweite Stützelement (20) herum mit mindestens einem Mutter/Schrauben-Element (52) angezogen und befestigt werden kann.

5. Prothesenvorrichtung nach einem der Ansprüche 1 bis 4, wobei das Fußelement (14) drehbar an dem zweiten Stützelement (20) befestigt ist, um zu ermöglichen, daß das Fußelement mit der Fußspitze nach innen oder nach außen gewandt eingestellt werden kann.

6. Prothesenvorrichtung nach einem der Ansprüche 1 bis 5, wobei sich die Blattfeder (24) entlang der Seite des ersten und zweiten Stützelementes (18, 20) erstreckt, wobei bei der Aufgabe einer Belastung auf das Fußprothesenelement (14) das erste und das zweite Stützelement relativ zueinander gleiten, dadurch die Blattfeder (24) zusammendrükken und ein Auslenken der Blattfeder nach außen bewirken.

7. Prothesenvorrichtung nach einem der Ansprüche 1 bis 6, wobei die Blattfeder (24) gelenkig an dem ersten und zweiten Stützelement (18, 20) befestigt ist.

8. Prothesenvorrichtung nach einem der Ansprüche 1 bis 6, wobei die Blattfeder (24) abnehmbar an dem ersten und zweit n Stützelement (18, 20) befestigt ist.

9. Prothesenvorrichtung nach einem der Ansprüche 1 bis 8, wobei eine Halterung (70) vorgesehen ist, um eine übermäßige Biegung der Blattfeder (24) zu begrenzen und dieser zu widerstehen.

10. Prothesenvorrichtung nach einem der Ansprüche 1 bis 9, wobei ein sekundäres Federelement (26) an der Blattfeder (24) befestigt ist und das sekundäre Federelement (26) flexible Enden aufweist, welche in Eingriff kommen, wenn sich die Blattfeder (24) auslenkt, um einer übermäßigen Biegung der Blattfeder zu widerstehen.

11. Prothesenvorrichtung nach einem der Ansprüche 1 bis 10, wobei das erste und zweite Stützelement (18, 20) koaxial in Bezug zueinander ausgerichtet sind.

12. Prothesenvorrichtung nach einem der Ansprüche 1 bis 11, wobei das erste und zweite Stützelement (18, 20) konzentrisch zueinander ausgerichtet sind.

13. Prothesenvorrichtung nach einem der Ansprüche 1 bis 12, wobei zumindest ein Teil der Oberfläche zwischen dem ersten und zweiten Stützelement (18, 20) mit Teflon beschichtet ist.

14. Prothesenvorrichtung nach einem der Ansprüche 1 bis 12, wobei zumindest ein Teil der Oberfläche zwischen dem ersten und zweiten Stützelement (18, 20) mit Silverstone beschichtet ist.

15. Prothesenvorrichtung nach einem der Ansprüche 1 bis 12, wobei zumindest ein Teil der Oberfläche zwischen dem ersten und zweiten Stützelement (18, 20) mit einem Material mit niedriger Reibung beschichtet ist.

16. Prothesenvorrichtung nach einem der Ansprüche 1 bis 15, wobei die Blattfeder (24) aus übereinandergelegten Laminaten hergestellt ist.

17. Prothesenvorrichtung nach einem der Ansprüche 1 bis 16, wobei das erste und zweite Stützelement (18, 20) eine rohrförmige Konfiguration aufweisen.

18. Prothesenvorrichtung nach einem der Ansprüche 1 bis 16, wobei das erste und zweite Stützelement (18, 20) eine Konfiguration mit quadratischem Querschnitt aufweisen.

19. Prothesenvorrichtung nach einem der Ansprüche 1 bis 16, wobei das erste und zweite Stützelement (18, 20) eine Konfiguration mit rechteckigem Querschnitt aufweisen.

20. Prothesenvorrichtung nach einem der Ansprüche 1 bis 16, wobei das erste und zweite Stützelement (18, 20) eine Konfiguration mit D-förmigem Querschnitt aufweisen.

21. Prothesenvorrichtung nach einem der Ansprüche 1

bis 20, wobei die Blattfeder (24) teilweise oder vollständig aus einem Duroplast hergestellt ist.

22. Prothesenvorrichtung nach einem der Ansprüche 1 bis 20, wobei die Blattfeder (24) teilweise oder vollständig aus einem Thermoplast hergestellt ist.

23. Prothesenvorrichtung nach einem der Ansprüche 1 bis 20, wobei die Blattfeder (24) teilweise oder vollständig aus Schnittfaser hergestellt ist.

24. Prothesenvorrichtung nach einem der Ansprüche 1 bis 19, wobei die Blattfeder (24) teilweise oder vollständig aus übereinandergelegten Laminaten hergestellt ist.

25. Stütze zur Verwendung mit einer Fußprothese zum Abstützen eines Amputierten in Bezug auf den Boden, mit:

einem oberen Stützelement (18) und einem zu dem oberen Element koaxial ausgerichteten unteren Stützelement (20), wobei das obere Element (20) und das untere Element (18) für ein Gleiten aneinander als Reaktion auf die Aufgabe von Belastungen auf die Stütze ausgebildet sind; und

einem mit dem oberen und unteren Element (18, 20) verbundenen flexiblen Federelement (22), wobei das Federelement ausgebildet ist, Energie zu speichern und abzugeben;

dadurch gekennzeichnet, daß
das flexible Federelement eine Blattfeder (24) aufweist und für eine Steuerung der relativen Axial- und Rotationsbewegung des ersten und zweiten Elementes (18, 20) angeordnet ist, wobei das Federelement (24) nicht-koaxial in Bezug auf die gemeinsame Achse des oberen und unteren Stützelementes (18, 20) auslenkt.

26. Stütze nach Anspruch 25, wobei das Federelement (22) nach außen auslenkt, wenn das obere und das untere Stützelement (18, 20) gleitend näher aneinander rücken.

27. Stütze nach Anspruch 25 oder 26, wobei die Blattfeder (24) ausgebildet ist, der Drehbewegung des oberen Elementes in Bezug auf das untere Element flexibel entgegenzuwirken.

28. Stütze nach Anspruch 25, 26 oder 27, wobei ein Hilfsfederelement (26) vorgesehen ist, um die übermäßige Auslenkung des Federelementes (24) zu begrenzen.

Revendicati ns

1. Dispositif de prothèse comprenant:

un premier (18) et un deuxième (20) montants, associés mutuellement ;
au moins un ressort (24), engageant de manière fonctionnelle lesdits premier et deuxième montants (18, 20), ledit ressort (24) étant capable d'emmagasiner et de libérer de l'énergie en réponse à l'application de charges sur ledit dispositif de prothése; et
un pied de prothèse (14), fixé audit deuxième montant;

caractérisé en ce que
ledit ressort comprend un ressort à lame (24), adapté à commander de manière flexible les mouvements axial et rotatif relatifs desdits premier et deuxième montants (18, 20).

2. Dispositif de prothèse selon la revendication 1, dans lequel le pied (14) est fixé de manière ajustable audit deuxième montant (20), de telle sorte que ce pied (14) puisse être ajusté de manière axiale et rotative par rapport audit deuxième montant.

3. Dispositif de prothèse selon la revendication 1 ou 2, dans lequel ledit pied (14) a une bride de fixation (48), qui peut être utilisée pour fixer celui-ci audit deuxième montant (20).

4. Dispositif de prothèse selon la revendication 3, dans lequel ladite bride de fixation (48) peut être serrée et fixée autour dudit deuxième montant (20) avec au moins un ensemble à boulon et écrou (52).

5. Dispositif de prothèse selon l'une quelconque des revendications 1 à 4, dans lequel ledit pied (14) est fixé à rotation audit deuxième montant (20) pour permettre à ce pied d'être tourné vers l'intérieur ou vers l'extérieur.

6. Dispositif de prothèse selon l'une quelconque des revendications 1 à 5, dans lequel ledit ressort à lame (24) s'étend le long du côté desdits premier et deuxième montants (18, 20), dans lequel, au moment du placement d'une charge sur ledit pied (14), lesdits premier et deuxième montants coulissent l'un par rapport à l'autre, en comprimant ainsi ledit ressort à lame (24) et en provoquant le fléchissement de ce ressort vers l'extérieur.

7. Dispositif de prothèse selon l'une quelconque des revendications 1 à 6, dans lequel ledit ressort à lame (24) est fixé à pivotement auxdits premier et deuxième montants (18, 20).

8. Dispositif de prothèse selon l'une quelconque des

revendications 1 à 6, dans lequel ledit ressort à lame (24) est fixé de manière détachable auxdits premier et deuxième montants (18, 20).

9. Dispositif de prothèse selon l'une quelconque des revendications 1 à 8, dans lequel une pièce de retenue (70) est prévue pour limiter et s'opposer au fléchissement excessif dudit ressort à lame (24).

10. Dispositif de prothèse selon l'une quelconque des revendications 1 à 9, dans lequel un ressort secondaire (26) est fixé au ressort à lame (24), ledit ressort secondaire (26) ayant des extrémités flexibles, engagées à mesure que ledit ressort à lame (24) se courbe pour s'opposer au fléchissement excessif de ce ressort à lame.

11. Dispositif de prothèse selon l'une quelconque des revendications 1 à 10, dans lequel lesdits premier et deuxième montants (18, 20) sont alignés coaxialement l'un par rapport à l'autre.

12. Dispositif de prothèse selon l'une quelconque des revendications 1 à 11, dans lequel lesdits premier et deuxième montants (18, 20) sont disposés concentriquement l'un par rapport à l'autre.

13. Dispositif de prothèse selon l'une quelconque des revendications 1 à 12, dans lequel au moins une portion de la surface entre lesdits premier et deuxième montants (18, 20) est revêtue de téflon.

14. Dispositif de prothèse selon l'une quelconque des revendications 1 à 12, dans lequel au moins une portion de la surface entre lesdits premier et deuxième montants (18, 20) est revêtue de "Silverstone".

15. Dispositif de prothèse selon l'une quelconque des revendications 1 à 12, dans lequel au moins une portion de la surface entre lesdits premier et deuxième montants (18, 20) est revêtue d'un matériau à faible frottement.

16. Dispositif de prothèse selon l'une quelconque des revendications 1 à 15, dans lequel ledit ressort à lame (24) est fabriqué à partir de lamelles superposées.

17. Dispositif de prothèse selon l'une quelconque des revendications 1 à 16, dans lequel lesdits premier et deuxième montants (18, 20) ont une configuration tubulaire.

18. Dispositif de prothèse selon l'une quelconque des revendications 1 à 16, dans lequel lesdits premier et deuxième montants (18, 20) ont une configuration à section transversale carrée.

19. Dispositif de prothèse selon l'une quelconque des revendications 1 à 16, dans lequel lesdits premier et deuxième montants (18, 20) ont une configuration à section transversale rectangulaire.

20. Dispositif de prothèse selon l'une quelconque des revendications 1 à 16, dans lequel lesdits premier et deuxième montants (18, 20) ont une configuration à section transversale en forme de D.

21. Dispositif de prothèse selon l'une quelconque des revendications 1 à 20, dans lequel ledit ressort à lame (24) est fabriqué partiellement ou entièrement à partir de résine thermodurcissable.

22. Dispositif de prothèse selon l'une quelconque des revendications 1 à 20, dans lequel ledit ressort à lame (24) est fabriqué partiellement ou entièrement à partir de résine thermoplastique.

23. Dispositif de prothèse selon l'une quelconque des revendications 1 à 20, dans lequel ledit ressort à lame (24) est fabriqué partiellement ou entièrement à partir de fibres découpées.

24. Dispositif de prothèse selon l'une quelconque des revendications 1 à 19, dans lequel ledit ressort à lame (24) est fabriqué partiellement ou entièrement à partir de lamelles superposées.

25. Montant, en vue d'une utilisation avec un pied de prothèse pour supporter un amputé par rapport au sol, comprenant:

un montant supérieur (18) et un montant inférieur (20), aligné coaxialement avec le montant supérieur, lesdits montants inférieur (20) et supérieur (18) étant adaptés pour coulisser l'un par rapport à l'autre en réponse à l'application de charges sur ces montants, et
un ressort flexible (22), connecté auxdits montants supérieur et inférieur (18, 20), ledit ressort étant adapté pour emmagasiner et libérer de l'énergie,

caractérisé en ce que
ledit ressort flexible comporte un ressort à lame (24) et est adapté à commander les mouvements axial et rotatif relatifs desdits montants supérieur et inférieur (18, 20), ledit ressort (24) fléchissant de manière non coaxiale par rapport à l'axe commun desdits montants supérieur et inférieur (18, 20).

26. Montant selon la revendication 25, dans lequel ledit ressort (24) fléchit vers l'extérieur à mesure que lesdits montants supérieur et inférieur (18, 20) se rapprochent l'un de l'autre, en coulissant.

27. Montant selon la revendication 25 ou 26, dans lequel ledit ressort (24) est adapté pour s'opposer de manière flexible au mouvement rotatoire dudit montant supérieur par rapport audit montant inférieur.

28. Montant selon la revendication 25, 26 ou 27, dans lequel un ressort auxiliaire (26) est prévu pour limiter le fléchissement excessif dudit ressort (24).

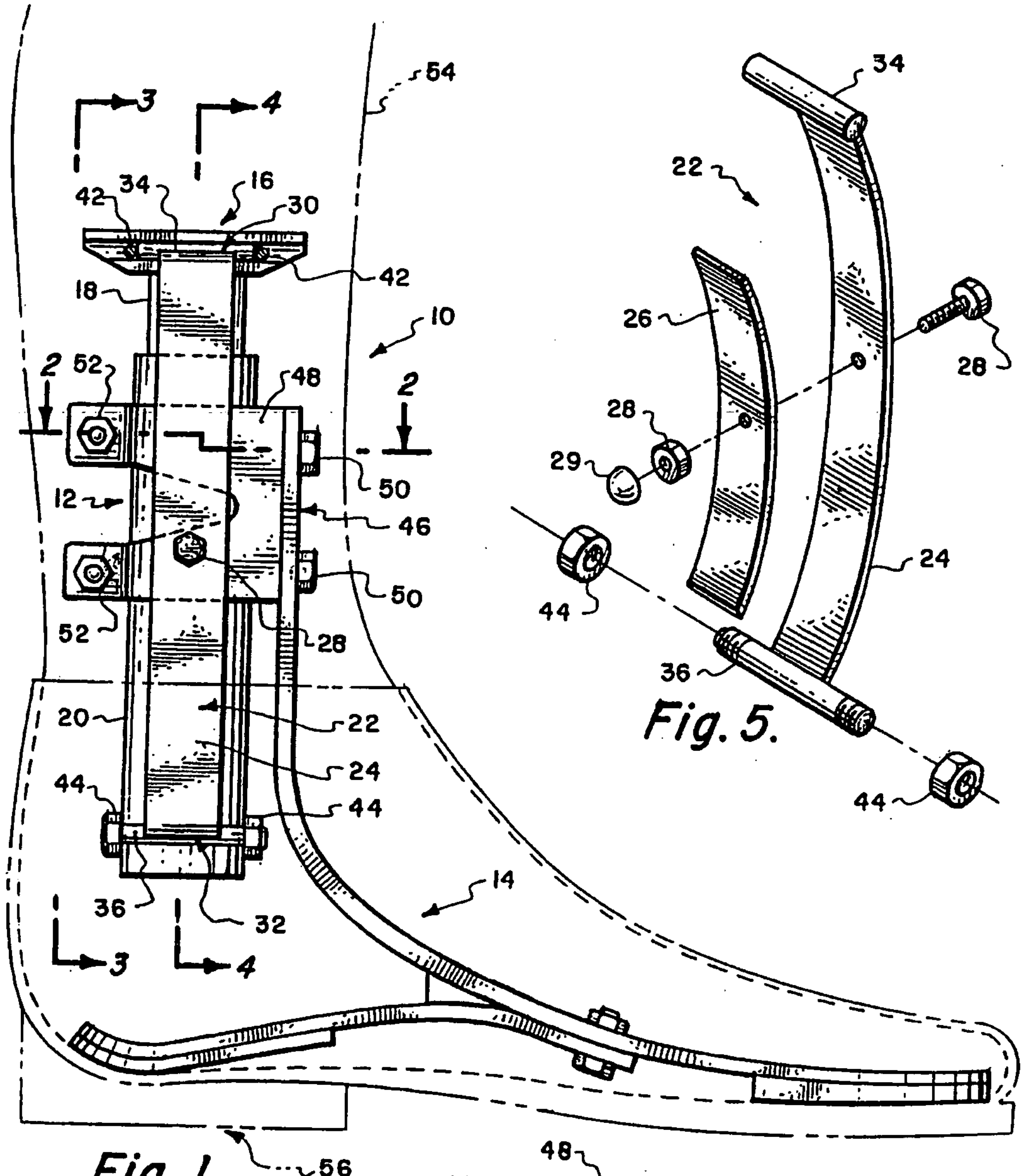

Fig. 1.

Fig. 5.

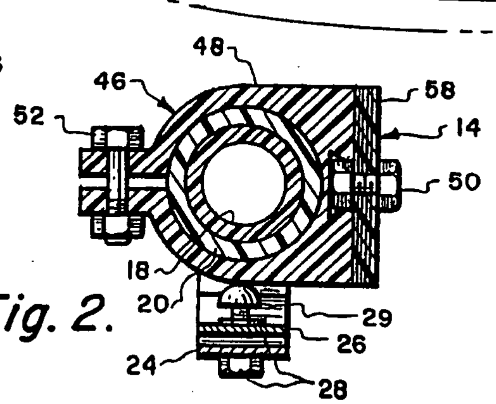

Fig. 2.

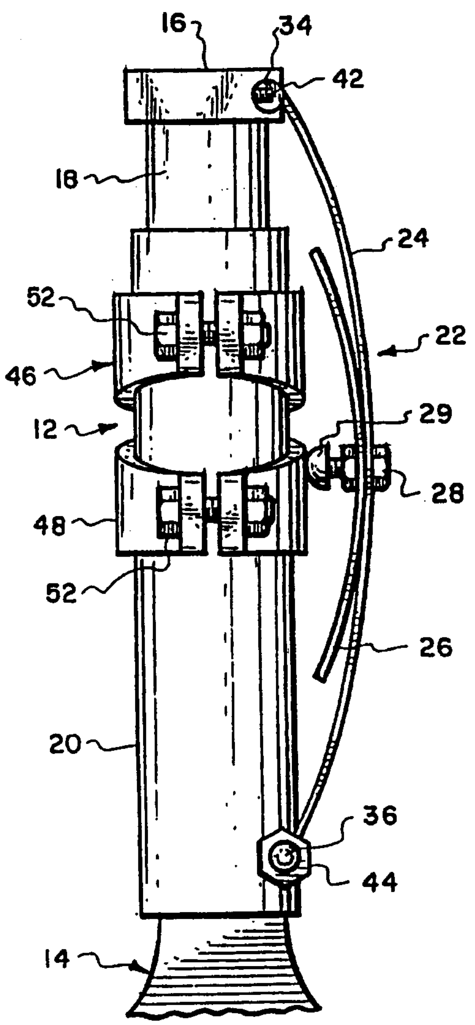
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Fig. 3.

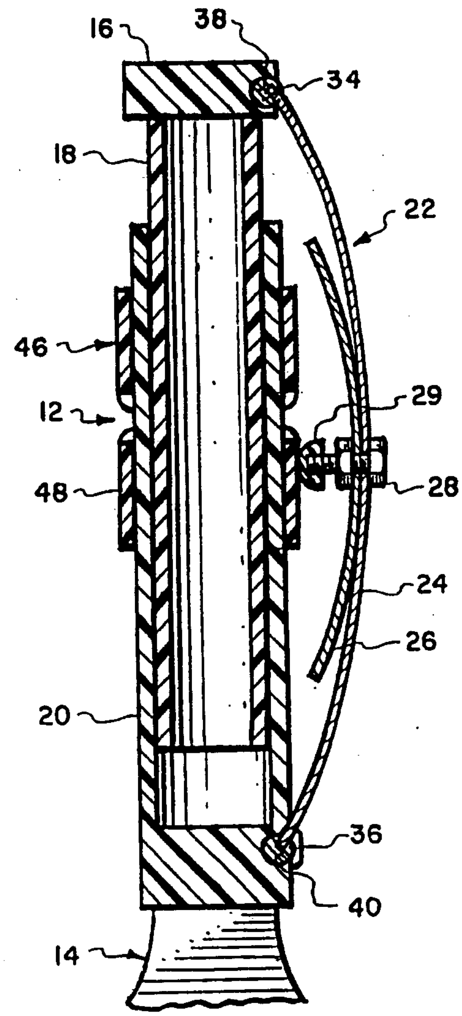
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Fig. 4.

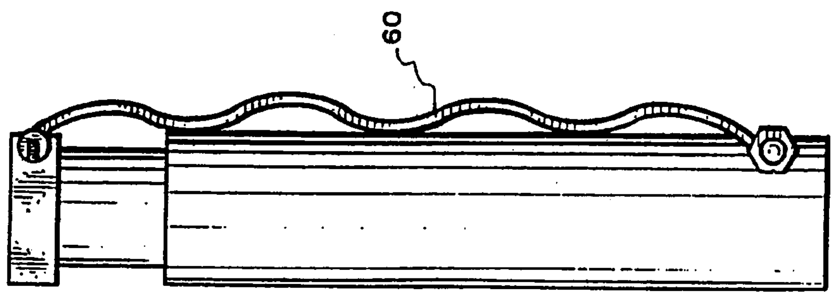

Fig. 7.

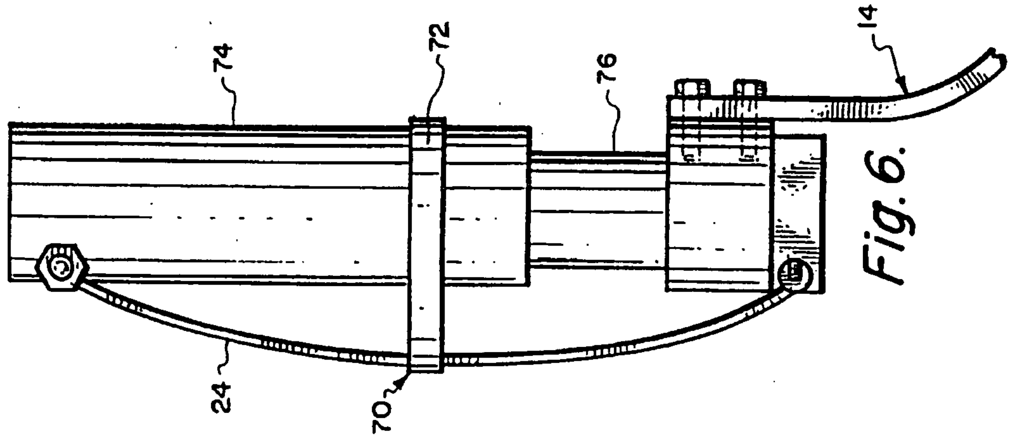

Fig. 6.

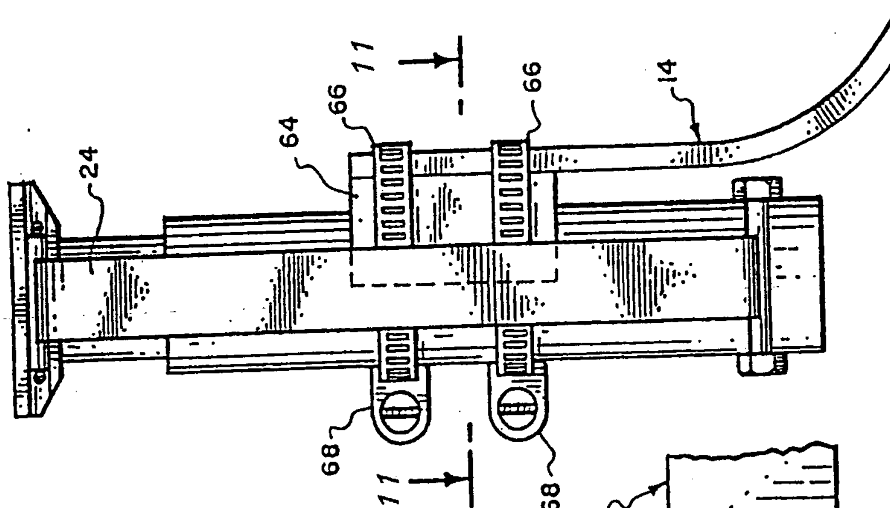

Fig. 10

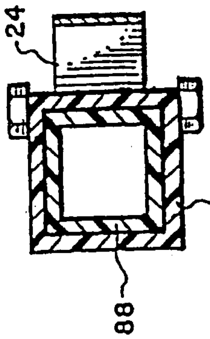

Fig. 9

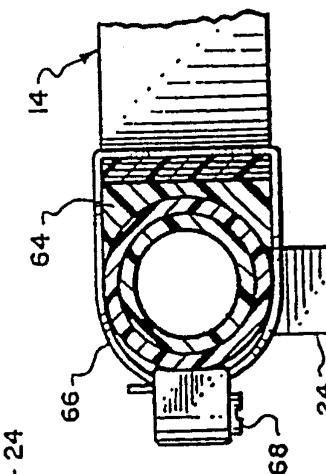

Fig. 11

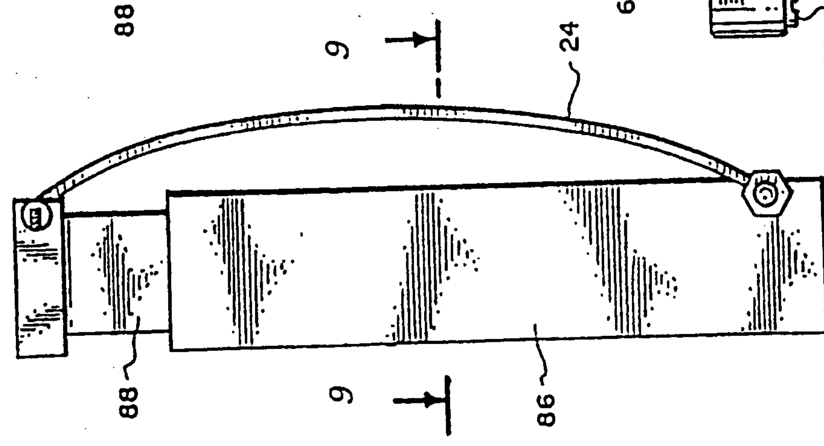

Fig. 8

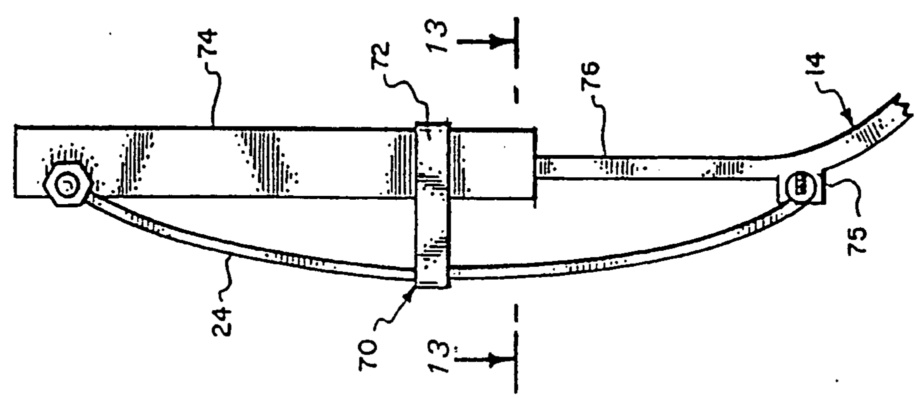

Fig. 12

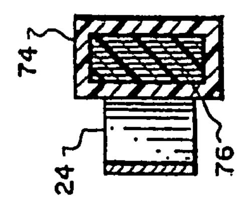

Fig. 13

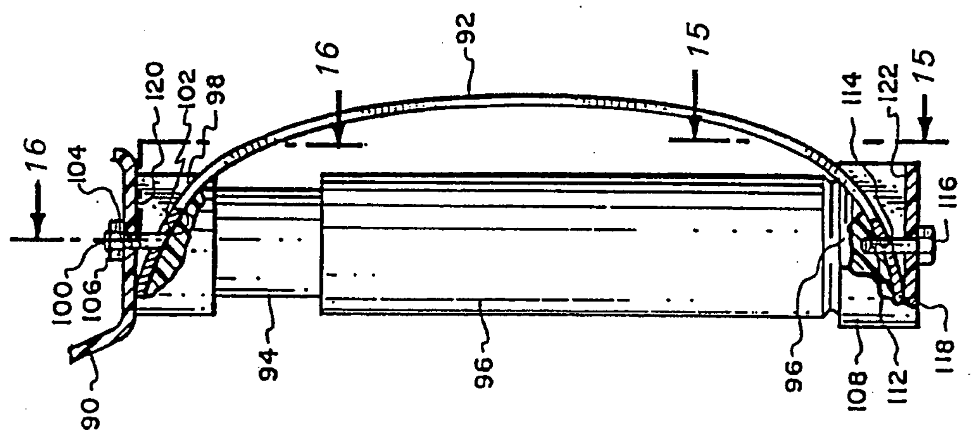

Fig. 14

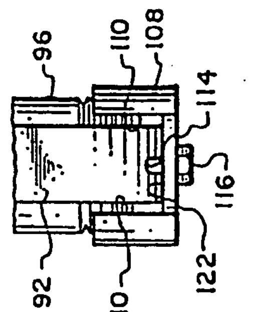

Fig. 15

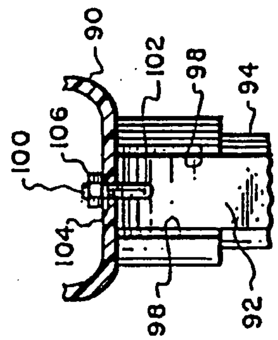

Fig. 16